CLAIMS

What is claimed is:

1. A natural gradient Blind Multi User Detection (BMUD) network system that adaptively estimates a set of matrices to counter a linear convolutive environment model r_n, the system comprising:

an input receptive of at least one of the linear convolutive environment model r_n or a whitened version r_n^w of the linear convolutive environment model r_n;

parametric matrices W_0 and W_k (k=1,2,... K) adaptable to estimate independent user symbols y_n at an n^{th} instant based on at least one of the linear convolutive environment model r_n or the whitened version r_n^w of the linear convolutive environment model r_n; and

a decision stage interpreting y_n and estimating corresponding user symbol estimates $\hat{b}_n$ also at the n^{th} instant.

2. The system of claim 1, wherein the system is networked in a feedforward configuration.

3. The system of claim 2, further comprising a recovery stage adapted to compute y_n according to:

$$y_n = W_0 r_n^w + \sum_{k=1}^{K} W_k r_{n-k}^w ,$$

where K is an estimate of a number of a previous symbols needed for computation of y_n, with K being greater than or equal to J:= integer (max (Tau_L)) + 1).

4. The system of claim 2, wherein the parametric matrices W_0 and W_k have update laws according to:

$$\Delta W_0 \propto \left(I - \varphi(y_n) y_n^H\right) W_0 \text{; and}$$

$$\Delta W_k \propto \left(I - \varphi(y_n) y_n^H\right) W_k - \varphi(y_n)\left(r_{n-k}^W\right)^H,$$

where $\varphi(\cdot)$ is an element-wise acting score function, I is a $\mathrm{K}-d$ identity matrix, and k=1,2,...K.

5. The system of claim 2, wherein W_0 is initially chosen to be at least one of an identity or a diagonally dominantly matrix, while all other matrices W_k are initialized to have at least one of random elements with a very small variance or as matrices of all zeros.

6. The system of claim 1, wherein the system is networked in a feedback configuration.

7. The system of claim 6, wherein the recovery stage is adapted to compute y_n according to:

$$y_n = W_0^{-1}\left(r_n^w - \sum_{k=1}^{K} W_k y_{n-k}\right).$$

8. The system of claim 6, wherein the parametric matrices W_0 and W_k have update laws according to:

$$\Delta W_0 \propto -W_0\left(I - \varphi(y_n) y_n^H\right); \text{ and}$$

$$\Delta W_k \propto W_0\left(\varphi(y_n) y_{n-k}^H\right),$$

where $\varphi(\cdot)$ is an element-wise acting score function, I is a $\mathrm{K}-d$ identity matrix, and k=1,2,...K, with K being an estimate of a number of previous symbols needed for computation of the parametric matrices, K being greater than or equal to J:= integer (max (Tau_L)) + 1).

9. The system of claim 1, wherein the system is networked in a feedback configuration without need for any matrix inversion.

10. The system of claim 9, wherein the decision stage is adapted to compute y_n according to:

$$y_n = W_0 r_n^w - \sum_{k=1}^{K} W_k y_{n-k} .$$

11. The system of claim 9, wherein the parametric matrices W_0 and W_k have update laws according to:

$$\Delta W_0 \propto \left(I - \varphi(y_n) y_n^H\right) W_0 ; \text{ and}$$

$$\Delta W_k \propto \left(I - \varphi(y_n) y_n^H\right) W_k + \varphi(y_n) y_{n-k}^H ,$$

where $\varphi(\cdot)$ is an element-wise acting score function, and I is a $\mathrm{K}-d$ identity matrix.

12. The system of claim 1, further comprising a whitening filter preprocessing received data for dimension reduction to K, which is an actual number of principal independent symbol sequences in the received data, and to remove second order dependence among received data samples and additive noise.

13. The system of claim 12, wherein the whitening filter whitens data online using adaptive principle component analysis computational techniques.

14. The system of claim 13, wherein the whitening filter whitens data using an algebraic PCA estimate over a large batch of received data including N samples according to:

$$R = \left[r_1 \; r_2 \cdots r_{\mathrm{N}-1} \quad r_{\mathrm{N}}\right]$$

with a data correlation matrix

$$\Lambda_c = \frac{1}{\mathrm{N}-1} R R^{\mathrm{T}} .$$

15. The system of claim 14, wherein the filter achieves the whitening using a filtering matrix according to:

$$W = D^{-1/2} V^T ,$$

where D represents a K-dim matrix of principle eigenvalues of the data correlation matrix Λ_C, and V represents a KxN matrix of principle eigen vectors of the data correlation matrix Λ_C, with K representing a number of users.

16. The system of claim 12, wherein the filter is adapted to calculate the whitened version r_n^w of the linear convolutive environment model r_n according to:

$$r_n^W = W(H_0 b_n + H_1 b_{n-1} + n_n) \cong \overline{H}_0 b_n + \overline{H}_1 b_{n-1},$$

and the linear convolutive environment model r_n is represented according to:

$$r_n = \mathrm{H}_0 b_n + \mathrm{H}_1 b_{n-1} + n_n$$

where b_n and b_{n-1} are the $\mathrm{K}-d$ vectors of current and previous symbols for all the K users, H_0 and H_1 are $\mathrm{K}\times\mathrm{K}$ mixing matrices with the structure $\mathrm{H}_0 = \lfloor \mathrm{H}_{0,0} \quad \mathrm{H}_{0,1} \quad \cdots \quad \mathrm{H}_{0,\mathrm{K}} \rfloor, \mathrm{H}_1 = \lfloor \mathrm{H}_{1,0} \quad \mathrm{H}_{1,1} \quad \cdots \quad \mathrm{H}_{1,\mathrm{K}} \rfloor$ such that $H_{0,k} = \sqrt{\varepsilon_0}\sum_{l=0}^{L-1} h_l \overline{z}_{kl}$, $\mathrm{H}_{l,k} = \sqrt{\varepsilon_1}\sum_{l=0}^{L-1} h_l \underline{z}_{kl}$, and $\varepsilon_{0,}\varepsilon_1$ represent the energy of the current and the previous symbol respectively.

17. An adaptive detector utilizing knowledge utilized by a RAKE receiver, comprising:

an adaptive weighting matrix introduced into a RAKE structure, wherein the matrix is adaptively estimated using at least one of Principal Component Analysis (PCA) computational techniques and static Blind Source Recovery (BSR) computational techniques.

18. The detector of claim 17, further comprising a closed form RAKE structure according to:

$$\hat{\hat{b}}_{i,RAKE-ICA/PCA} = \begin{cases} S_i^H \tilde{W} \hat{H}^H \bar{r} & \textit{for DS-CDMA Systems} \\ S_i^H C^H \tilde{W} \hat{H}^H \bar{r} & \textit{for WCDMA Systems} \end{cases}$$

where $\tilde{W} = diag[\mathrm{A}\,\mathrm{A} \cdots \mathrm{A}]$, and A is the matrix.

19. The detector of claim 18, wherein $\tilde{W}(or\ A)$ is adapted according to natural gradient update laws.

20. The detector of claim 19, wherein the matrix is adaptively estimated using natural gradient update laws according to:

$$A(k+1) = A(k) + \eta_k \Delta A(k).$$

21. The detector of claim 20, where

$$\Delta A(k) = \begin{cases} (I - \varphi(y(k))y(k)^H)A(k) & \text{for static BSR (or ICA)} \\ (I - y(k)y(k)^H)A(k) & \text{for PCA} \end{cases}$$

and $\varphi(\cdot)$ is a nonlinear score function which depends on an underlying distribution structure of involved signals.

22. The detector of claim 21, wherein the score function is in the form:

$$\varphi_i(y_i) = \upsilon_i y_i - \alpha_i\left(\tanh(\beta_i \operatorname{Re}\{y_i\}) + \tanh(\beta_i \operatorname{Im}\{y_i\})\right).$$

23. The detector of claim 17, wherein a channel estimate $\hat{\mathrm{H}}$ is at least one of not available or changes dynamically, and the detector is estimated without using the channel estimate, such that the structure reduces to Matched Filter (MF) BSR/PCA according to:

$$\hat{\hat{b}}_{i,MF-BSR/PCA} = \begin{cases} s_i^H \tilde{W} \tilde{r} & \text{for DS-CDMA Systems} \\ s_i^H C^H \tilde{W} \tilde{r} & \text{for WCDMA Systems} \end{cases}.$$

24. A natural gradient Blind Multi User Detection (BMUD) method that adaptively estimates a set of matrices to counter a linear convolutive environment model r_n, comprising:

receiving at least one of the outputs of the linear convolutive environment model r_n or a whitened version r_n^w of the outputs of the linear convolutive environment model r_n;

adapting parametric matrices W_0 and W_k to estimate independent user symbols y_n at an n^{th} instant based on at least one of the linear convolutive environment model r_n and the whitened version r_n^w of the linear convolutive environment model r_n; and

interpreting y_n and estimating corresponding user symbol estimates $\hat{b}_n$ also at the n^{th} instant.

25. The method of claim 24, further comprising employing a feedforward network configuration.

26. The method of claim 25, further comprising computing y_n according to:

$$y_n = W_0 r_n^w + \sum_{k=1}^{K} W_k r_{n-k}^w .$$

27. The method of claim 25, further comprising updating the parametric matrices W_0 and W_k via update laws according to:

$$\Delta W_0 \propto \left(I - \varphi(y_n) y_n^H\right) W_0 \text{; and}$$

$$\Delta W_k \propto \left(I - \varphi(y_n) y_n^H\right) W_k - \varphi(y_n) \left(r_{n-k}^W\right)^H ,$$

where $\varphi(\cdot)$ is an element-wise acting score function, and I is a $\mathrm{K}-d$ identity matrix.

28. The method of claim 25, further comprising:

initializing W_0 to be at least one of an identity or a diagonally dominant matrix; and

initializing all other matrices W_k to have at least one of random elements with a very small variance or as matrices of all zeros.

29. The method of claim 24, further comprising employing a feedback network configuration.

30. The method of claim 29, further comprising computing y_n according to:

$$y_n = W_0^{-1}\left(r_n^w - \sum_{k=1}^{K} W_k y_{n-k} \right).$$

31. The method of claim 29, updating the parametric matrices W_0 and W_k via update laws according to:

$$\Delta W_0 \propto -W_0\left(I - \varphi(y_n) y_n^H\right); \text{ and}$$

$$\Delta W_k \propto W_0\left(\varphi(y_n) y_{n-k}^H\right),$$

where $\varphi(\cdot)$ is an element-wise acting score function, and I is a $\mathrm{K}-d$ identity matrix.

32. The method of claim 24, further comprising employing a feedback network configuration without need for any matrix inversion.

33. The method of claim 32, further comprising computing y_n according to:

$$y_n = W_0 r_n^w - \sum_{k=1}^{K} W_k y_{n-k} .$$

34. The method of claim 32, further comprising updating the parametric matrices W_0 and W_k via update laws according to:

$$\Delta W_0 \propto \left(I - \varphi(y_n) y_n^H\right) W_0; \text{ and}$$

$$\Delta W_k \propto \left(I - \varphi(y_n) y_n^H\right) W_k + \varphi(y_n) y_{n-k}^H,$$

where $\varphi(\cdot)$ is an element-wise acting score function, and I is a $\mathrm{K}-d$ identity matrix.

35. The method of claim 24, further comprising preprocessing received data for dimension reduction to K, which is an actual number of principal independent symbol sequences in the received data, and to remove second order dependence among received data samples and additive noise.

36. The method of claim 35, further comprising whitening data online using adaptive principle component analysis computational techniques.

37. The method of claim 36, further comprising whitening data using an algebraic PCA estimate over a large batch of received data including N samples according to:

$$R = \lfloor r_1\ r_2 \cdots r_{\mathrm{N}-1}\quad r_{\mathrm{N}} \rfloor$$

with a data correlation matrix

$$\Lambda_C = \frac{1}{\mathrm{N}-1} RR^{\mathrm{T}}.$$

38. The method of claim 36, further comprising employing a filtering matrix according to:

$$W = D^{-1/2} V^T$$

where D represents a K-dim matrix of principle eigenvalues of the data correlation matrix Λ_C, and V represents a KxM matrix of principle eigen vectors of the data correlation matrix Λ_C.

39. The method of claim 35, further comprising calculating the whitened version r_n^w of the linear convolutive environment model r_n according to:

$$r_n^w = W(H_0 b_n + H_1 b_{n-1} + n_n) \cong \overline{H}_0 b_n + \overline{H}_1 b_{n-1},$$

wherein the linear convolutive environment model r_n is represented according to:

$$r_n = \mathrm{H}_0 b_n + \mathrm{H}_1 b_{n-1} + n_n$$

where b_n and b_{n-1} are the $\mathrm{K}-d$ vectors of current and previous symbol for all the K users, H_0 and H_1 are $G \times \mathrm{K}$ mixing matrices with the structure $\mathrm{H}_0 = \lfloor \mathrm{H}_{0,0} \quad \mathrm{H}_{0,1} \quad \cdots \quad \mathrm{H}_{0,\mathrm{K}} \rfloor, \mathrm{H}_1 = \lfloor \mathrm{H}_{1,0} \quad \mathrm{H}_{1,1} \quad \cdots \quad \mathrm{H}_{1,\mathrm{K}} \rfloor$ such that $H_{0,k} = \sqrt{\varepsilon_0} \sum_{l=0}^{L-1} h_l \bar{z}_{kl}$, $\mathrm{H}_{l,k} = \sqrt{\varepsilon_1} \sum_{l=0}^{L-1} h_l \underline{z}_{kl}$, and $\varepsilon_0, \varepsilon_1$ represent the energy of the current and the previous symbol respectively.

40. An adaptive detection method, comprising:

introducing an adaptive weighting matrix into a RAKE structure, wherein the matrix is adaptively estimated using at least one of Principal Component Analysis (PCA) computational techniques or static Blind Source Recovery (BSR) computational techniques based on Independent Component Analysis (ICA).

41. The method of claim 40, further comprising employing a closed form RAKE structure according to:

$$\hat{\hat{b}}_{i,RAKE-ICA/PCA} = \begin{cases} S_i^H \tilde{W} \hat{H}^H \bar{r} & \textit{for DS-CDMA Systems} \\ S_i^H C^H \tilde{W} \hat{H}^H \bar{r} & \textit{for WCDMA Systems} \end{cases}$$

where $\tilde{W} = diag[\mathrm{A}\,\mathrm{A} \cdots \mathrm{A}]$, and A is the matrix.

42. The method of claim 41, further comprising adapting the matrix according to natural gradient update laws.

43. The method of claim 42, further comprising adaptively estimating the matrix using natural gradient update laws according to:

$$A(k+1) = A(k) + \eta_k \Delta A(k)$$

where

$$\Delta A(k) = \begin{cases} (I-\varphi(y(k))y(k)^H)A(k) & \text{for static BSR (or ICA)} \\ (I-y(k)y(k)^H)A(k) & \text{for PCA} \end{cases}$$

and $\varphi(\cdot)$ is a nonlinear score function which depends on an underlying distribution structure of involved signals.

44. The method of claim 43, further comprising employing a score function according to:

$$\varphi_i(y_i) = \upsilon_i y_i - \alpha_i\left(\tanh(\beta_i \operatorname{Re}\{y_i\}) + \tanh(\beta_i \operatorname{Im}\{y_i\})\right).$$

45. The method of claim 40, wherein a channel estimate $\hat{\mathrm{H}}$ is at least one of not available and changes dynamically, the method further comprising estimating a detector without using the channel estimate, such that the detector structure reduces to Matched Filter BSR/PCA according to:

$$\hat{\tilde{b}}_{i,MF-BSR/PCA} = \begin{cases} s_i^H \tilde{W} r & \text{for DS-CDMA Systems} \\ s_i^H C^H \tilde{W} r & \text{for WCDMA Systems} \end{cases}.$$